Ole A. Sæther & Trond Andersen

Museum of Zoology, University of Bergen

FIRST AFROTROPICAL RECORDS OF *DOITHRIX* AND *GEORTHOCLADIUS*, WITH NOTES ON THE *PSEUDORTHOCLADIUS* GROUP (DIPTERA: CHIRONOMIDAE)

Sæther, O. A. & Andersen, T., 1996. First Afrotropical records of *Doithrix* and *Georthocladius*, with notes on the *Pseudorthocladius* group (Diptera: Chironomidae). - Tijdschrift voor Entomologie 139: 243-256, figs 1-29 [ISSN 0040-7496]. Published 18 December 1996.

The diagnoses of the genera *Doithrix* Sæther et Sublette and *Georthocladius* Strenzke are emended. *Toyamayusurika* Sasa et Kawai is shown to be a junior synonym of *Georthocladius*. The male imagines of the new species *Doithrix longipes*, *Doithrix amegabei*, *Georthocladius longicalcaneum*, and *Georthocladius amakyei*, all from Ghana, are described. Eight new combinations are given: *Doithrix fujiseptimus* (Sasa) comb. n., *Doithrix togateformis* (Sasa, Watanabe et Arakawa) comb. n., *Georthocladius asamasextus* (Sasa et Hirabayashi) comb. n., *Georthocladius fujiquinta* (Sasa) comb. n., *Georthocladius shiotanii* (Sasa et Kawai) comb. n., *Pseudorthocladius amamikonaseus* (Sasa et Suzuki) comb. n., *Pseudorthocladius kurobesugoidus* (Sasa et Okazawa) comb. n., and *Pseudorthocladius togakuroidus* (Sasa, Watanabe et Arakawa) comb. n.

The morphological expressions of adaptations by chironomid male imagines to tropical areas are discussed. These adaptations often, but not always, consist in considerably smaller size and associated lower number of setae, reduction of eye elongation, considerably shorter antennal ratio, loss or reduction of the anal lobe of the wing, loss of setae on squama, longer costal extension, longer front metatarsus resulting in higher front leg ratio and, at least in orthoclads, reduction of the inferior volsella.

O. A. Sæther & T. Andersen, Museum of Zoology, University of Bergen, Muséplass 3, N-5007 Bergen, Norway.

Keywords. - Chironomidae, Afrotropical, new species, *Doithrix*, *Georthocladius*, adaptations.

The *Pseudorthocladius* group consists of the four closely related genera *Parachaetocladius* Wülker, *Doithrix* Sæther et Sublette, *Georthocladius* Strenzke, and *Pseudorthocladius* Goetghebuer. While the immatures of the first of these genera, *Parachaetocladius*, live in springs, streams and rivers, the other three genera all are semiterrestrial to semiaquatic living in a variety of damp habitats including mosses, hygropetric regions, seepages and floodplains along stream banks (Strenzke 1950, Sæther & Sublette 1983, Cranston et al. 1989).

The genus group was revised by Sæther & Sublette (1983) showing that it forms a well delineated monophyletic group with *Metriocnemus* v.d. Wulp plus *Thienemannia* Kieffer as the likely sister group. The genus *Doithrix* was emended slightly by Cranston & Oliver (1988). Within the *Pseudorthocladius* group *Doithrix* plus *Georthocladius* apparently form the sister group of *Pseudorthocladius* plus *Parachaetocladius*. The presence of well developed pulvilli, naked eyes, an apical antennal seta, acrostichals absent or long and beginning near the antepronotum, curved Cu, and an anal point with strong setae and microtrichiae to apex or nearly to apex will separate the *Pseudorthocladius* group from other orthoclad genera.

In connection with a project in Ghana supported by the Norwegian Universities' Commitee for Development, Research and Education (NUFU), four new species belonging to the *Pseudorthocladius* group were found. These finds are interesting not only because they represent the first Afrotropical finds of the genera *Doithrix* and *Georthocladius*, but also because their morphology indicate some common trends of adaptations to tropical rain forests.

Methods and morphology

The mounting procedure used is outlined by Sæther (1969). Morphological nomenclature follows Sæther (1980). The measurements are given as ranges followed by a mean when four or more measurements are made, followed by the number measured in parentheses (n).

The holotypes of the new species are deposited at the Museum of Zoology (ZMBN), University of Bergen, Bergen, Norway.

Doithrix Sæther et Sublette

Doithrix Sæther et Sublette, 1983: 6.

Type species. – *Doithrix villosa* Sæther et Sublette, 1983: 9.

Diagnosis of male imago. – As in Sæther & Sublette (1983: 6) and Cranston et al. (1989: 191) with the following emendations: Minute to moderately small species, wing length 0.7-2.0 mm. Antennal ratio between 0.2 and 2.0. Eyes without or with very slight eye elongation. Antepronotum moderately to well developed. Dorsocentrals extending well forward, single to triple in front; acrostichals extending to one third to half the length of scutum from antepronotum; prealars few to numerous, when few in anterior and posterior group. Scutellum with setae in uni - biserial transvetse row. Anal lobe of wing well developed to very weak, usually protruding. Virga consisting of at most about 6 very fine spines or occasionally absent. Gonocoxite with strong, posteriorly directed, apically pointed or rounded inferior volsella or occasionally inferior volsella broad based, relatively low and subtriangular or reduced. Gonostylus with or without expanded base, apically strongly attenuate to truncate or slender and approximately evenly wide for its full length; with a few to numerous long setae on inner margin.

Included species. – In addition to the four species described by Sæther & Sublette (1983) and *Doithrix dillonae* Cranston et Oliver described by Cranston & Oliver (1988), Wang (1994) described *Doithrix emeiensis* Wang from China (examined by the senior author), and two species described from Japan in other genera clearly belong to *Doithrix*, namely *Doithrix fujiseptimus* (Sasa), **comb. n.** described as *Pseudorthocladius fujiseptimus* in Sasa (1985: 126); and *Doithrix togateformis* (Sasa, Watanabe et Arakawa) **comb. n.** described as *Toyamayusurika togateformis* in Sasa, Watanabe et Arakawa (1992: 235). Both are typical *Doithrix*, the first nearly identical to *D. emeiensis* and possibly close to *D. hamiltoni* Sæther et Sublette and *D. barberi* Sæther et Sublette, all four sharing synapomorphies in the hook-like inferior volsellae and other details; and the second probably close to *D. ensifer* Sæther et Sublette sharing a synapomorphy in the basal swelling of the gonostylus. Ueno & Iwakuma (1996) recorded *D. villosa* Sæther et Sublette from the Miyatoko mire in Japan.

Doithrix longipes sp. n.
(figs. 1-7)

Type material. – Holotype •, Ghana: Western region, Ankasa Game Production Reserve, 6-12.xii.1993, NUFU project (ZMBN No. 173). – Paratypes: 3 • as holotype.

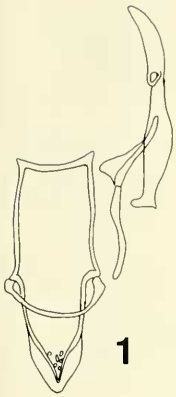
Diagnostic characters. – The small size (wing length 0.7-0.8 mm), extremely long metatarsus giving an LR_1 of 1.01-1.04, the very long costal extension, absence of setae on squama and the evenly wide gonostylus will separate the species from all other *Doithrix* except *D. amegabei* sp. n. described below. The short antennal ratio (0.2-0.3), the subtriangular inferior volsella, and the shorter and less sclerotized phallapodeme will separate *D. longipes* from *D. amegabei*.

Male imago (n = 4 except when otherwise stated). – Total length 1.41-1.54, 1.47 mm. Wing length 0.73-0.77, 0.74 mm. Total length / wing length 1.90-2.01, 1.98. Wing length / length of profemur 2.62-2.75, 2.68. Coloration pale brown with vittae, median anepisternum II, ventral part of preepisternum and postnotum dark brown.

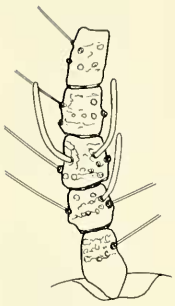
Head (figs. 1-3). AR 0.23-0.27, 0.25. Ultimate flagellomere 77-109, 87 µm long; apical seta 30-45, 37 µm long. Flagellomere 2 with 1 sensilla chaetica, 29-36 µm long; flagellomere 3 with 2 sensilla chaetica, 28-36 and 33-38 µm long, the longest about 3 µm wide. Temporal setae 8-19, 9; including 3-4, 4 inner verticals; 2-3, 3 outer verticals; and 2-4, 3 postorbitals. Clypeus with 6 setae. Tentorium 77-86, 84 µm long; 8-13, 10 µm wide. Stipes 60-71, 66 µm long, 15-23, 19 µm wide. Palp with 5 palpomeres, lengths (in µm): 15-23, 18; 23-30, 25; 45-49, 47; 56-71, 62; 75-94, 82. Third palpomere with about 6-7 sensilla clavata in 2-3 groups; fourth palpomere with 0-1 apical sensillum clavatum.

Thorax (fig. 4). Antepronotum with 4 setae. Dorsocentrals 8-11, 10; acrostichals about 6-8; prealars 4-5, 5, including 2-3, 3 posterior and 1-3, 2 anterior prealars. Scutellum with 4 setae.

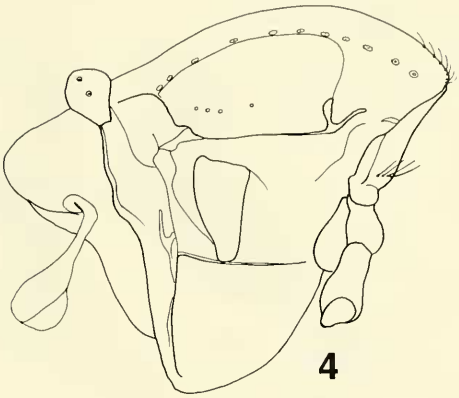
Figs 1-8. *Doithrix longipes* sp. n., male imago. - 1, Cibarial pump, tentorium and stipes; 2, Third palpomere; 3, Flagellomere 1 to 5, showing the sensilla chaetica on flagellomeres 2 and 3; 4, Thorax; 5, Wing; 6, Anal point and dorsal aspect of left gonocoxite and gonostylus; 7, Hypopygium with anal point and laterosternite IX removed, left dorsal aspect, right ventral aspect; 8, Gonostylus, ventral aspect.



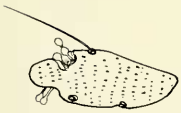
1



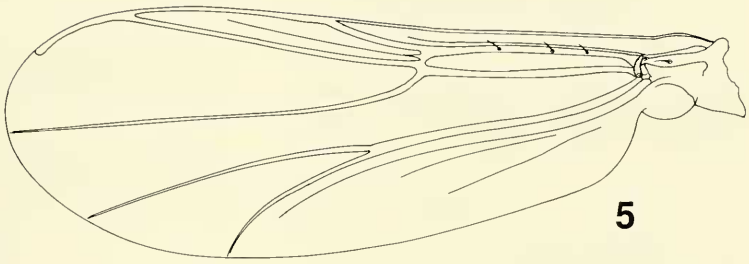
3



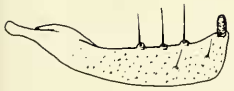
4



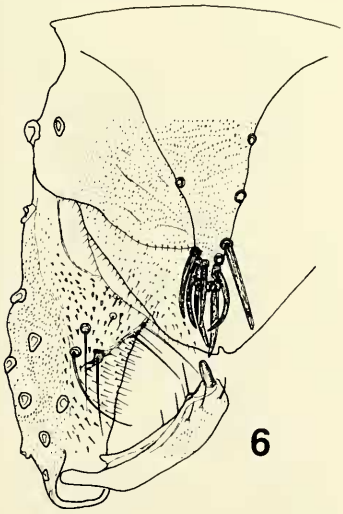
2



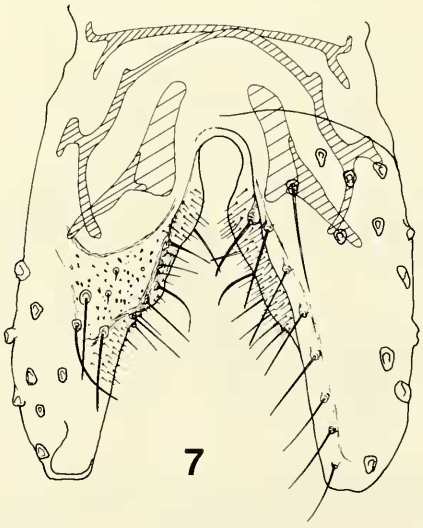
5



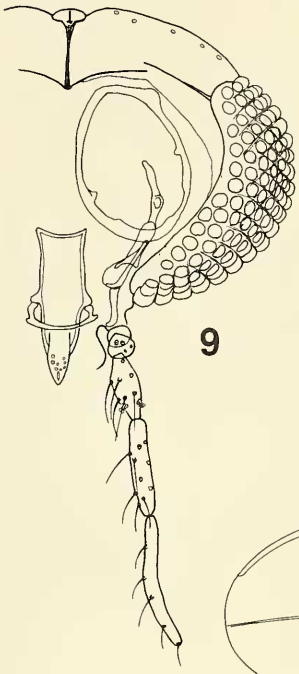
8

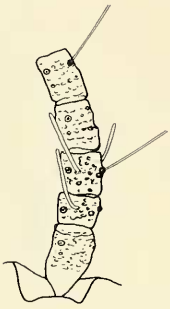


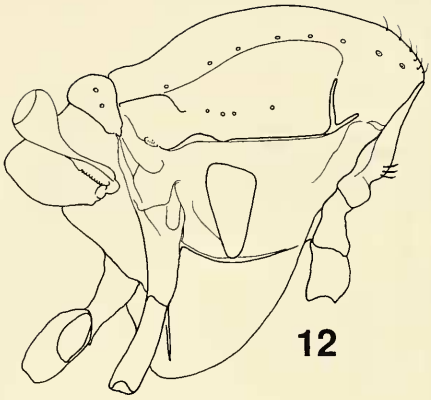
6

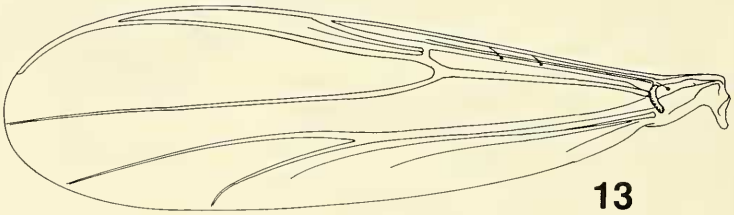


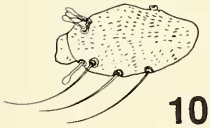
7

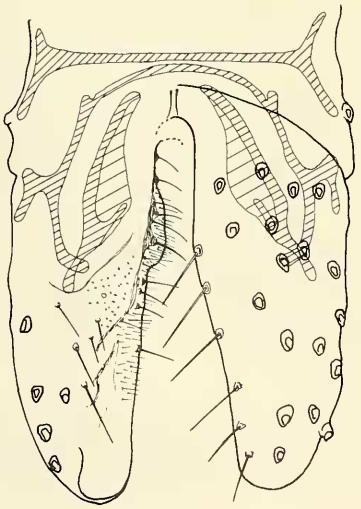

9


11


12


13


10


15

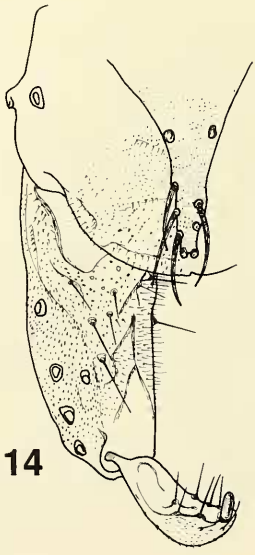

14

Table 1. Lengths (in µm) and proportions of legs of male imago of *Doithrix longipes* sp. n.

	fe	ti	ta_1	ta_2
p_1	274-278, 277	255-263, 258	259-266, 264	113-120, 117
p_2	281-285, 283	283-295, 292	112-114, 113	53-60, 56
p_3	274-285, 280	315-319, 317	182-184, 183	83-84, 84
	ta_3	ta_4	ta_5	LR
p_1	77-84, 81	49-51, 50	34-39, 37	1.01-1.04, 1.02
p_2	41-43, 42	24-30, 27	24-28, 26	0.38-0.39, 0.39
p_3	86-90, 88	34-38, 36	30-38, 33	0.56-0.58, 0.57
	BV	SV	BR	
p_1	2.78-287, 2.82	1.99-2.06, 2.02	2.1-3.0, 2.6	
p_2	4.31-4.70, 4.56	5.07-5.13, 5.11	2.3-3.1, 2.8	
p_3	3.12-3.34, 3.24	3.20-3.40, 3.29	2.9-3.7, 3.4	

Wing (fig. 5). VR 1.36-1.50 (3). Anal lobe weak, not projecting. C extension 83-101, 91 µm long. Brachiolum with 1 seta; R with 3-4, 4 setae; other veins bare. Squama bare.

Legs. Spur of front tibia 34 µm long; spurs of middle tibia 23-26, 24 µm and 15-19, 18 µm long; of hind tibia 38-41, 39 µm and 17-19, 19 µm long. Width at apex of front tibia 21-23, 23 µm; of middle tibia 21-23, 22 µm; of hind tibia 28-30, 29 µm. Hind tibial comb with 11 setae; shortest setae 19-26, 24 µm long; longest setae 32-34, 34 µm long. Lengths and proportions of legs as in table 1.

Hypopygium (figs. 6-8). Anal point 34-43, 40 µm long; with 12-15, 14 lamellate setae; longest setae 17-21, 20 µm long. Laterosternite IX with 2 setae. Phallapodeme 38-49, 45 µm long; transverse sternapodeme 36-41, 39 µm long. Virga absent or perhaps minute virga indicated in some specimens. Gonocoxite 98-100, 99 µm long; inferior volsella relatively low, subtriangular, without posterior projection. Gonostylus 51-53, 52 µm long; evenly wide; with about 3 strong preapical setae on inner margin; megaseta 6-9, 7 µm long. HR 1.86-1.93, 1.90; HV 2.76-2.91, 2.82.

Etymology. – From Latin, *longus*, long, and *pes*, gen. *pedis*, foot, referring to the extremely long metatarsus of the front leg.

Remarks. – *D. longipes* sp. n. and *D. amegabei* sp. n. differ in very many aspects from the previously described members of the genus and may eventually deserve their own subgenus or even a separate genus. However, most of these differences can be seen as a result of the tiny size and of adaptations to a life in tropical rain forests. Similar adaptations seem to occur also in other tropical chironomids including those described below.

Distribution. – The species is known only from a rain forest in western Ghana close to the border with the Ivory Coast.

Doithrix amegabei sp. n.
(figs. 9-15)

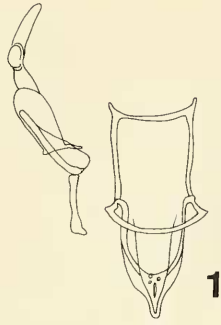
Type material. – Holotype ♂, Ghana: Western region, Ankasa Game Production Reserve, 6-12.xii.1993, NUFU project (ZMBN No. 174).

Diagnostic characters. – The species differs from *D. longipes* sp. n. by having a higher AR (0.47), reduced inferior volsella of the hypopygium and a longer and more sclerotized phallapodeme. It also appears to have some rudiments of a virga.

Male imago (n = 1). – Total length 1.50 mm. Wing length 0.77 mm. Total length / wing length 1.95. Wing length / length of profemur 2.70. Coloration pale brown with vittae, median anepisternum II, ventral part of preepisternum and postnotum blackish brown.

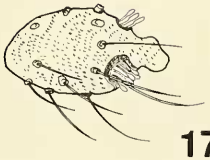
Head (figs. 9-11). AR 0.47. Ultimate flagellomere 154 µm long, apical seta 38 µm long. Flagellomere 2 with 1 sensilla chaetica, 22 µm long; flagellomere 3

Figs 9-15. *Doithrix amegabei* sp. n., male imago. - 9, Head; 10, Third palpomere; 11, Flagellomere 1 to 5, showing the sensilla chaetica on flagellomeres 2 and 3; 12, Thorax; 13, Wing; 14, Anal point and dorsal aspect of left gonocoxite and gonostylus; 15, Hypopygium with anal point and laterosternite IX removed, left dorsal aspect, right ventral aspect.

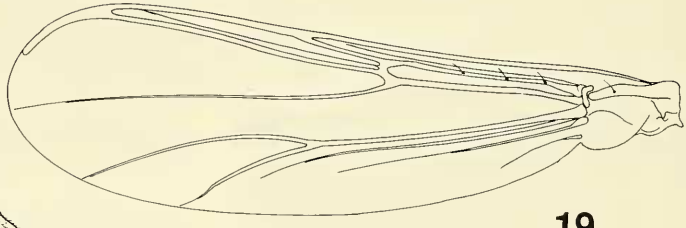


16

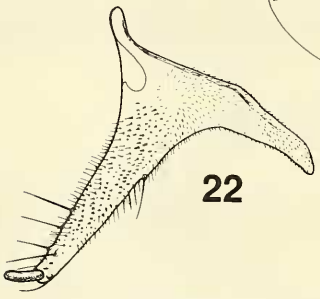
18



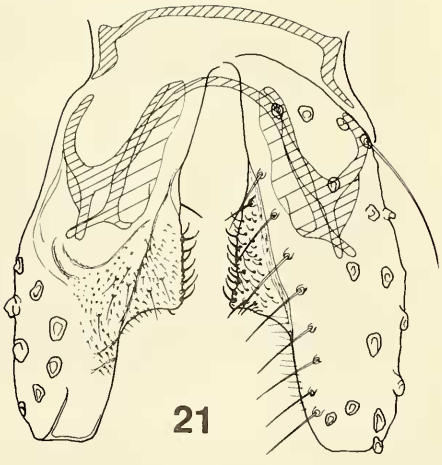
17



19



22



21

20

Table 2. Lengths (in µm) and proportions of legs of male imago of *Doithrix amegabei* sp. n.

	fe	ti	ta_1	ta_2	ta_3	ta_4	ta_5	LR	BV	SV	BR
p_1	285	270	278	163	120	73	41	1.03	2.10	2.00	3.0
p_2	293	296	126	68	45	28	30	0.42	4.19	4.69	-
p_3	293	330	191	98	90	39	32	0.58	2.68	3.16	3.3

with 2 sensilla chaetica, 21 and 25 µm long, the longest less than 2 µm wide. Temporal setae 8, including 3 inner verticals, 2 outer verticals, and 3 postorbitals. Clypeus with 6 setae. Tentorium 71 µm long, 8 µm wide. Stipes 64 µm long, 15 µm wide. Palp with 5 palpomeres, lengths (in µm): 19, 23, 41, 45, 84. Third palpomere with about 6 sensilla clavata in 2 groups, fourth palpomere apparently without apical sensillum clavatum.

Thorax (fig. 12). Antepronotum with 3 setae. Dorsocentrals 8; acrostichals about 6; prealars 4, including 3 posterior and 1 anterior prealar. Scutellum with 4 setae.

Wing (fig. 13). VR 1.40. Anal lobe reduced, not projecting. C extension 83 µm long. Brachiolum with 1 seta, R with 2 setae, other veins bare. Squama bare.

Legs. Spur of front tibia 41 µm long, spurs of middle tibia 17 µm and 23 µm long, of hind tibia 38 µm and 21 µm long. Width at apex of front tibia 19 µm, of middle tibia 21 µm, of hind tibia 24 µm. Comb with 11 setae, 23-30 µm long. Lengths and proportions of legs as in table 2.

Hypopygium (figs. 14, 15). Anal point 38 µm long; with 9 lamellate setae, setae about 24 µm long; laterosternite IX with 2 setae. Phallapodeme 56 µm long, aedeagal lobe well sclerotized; transverse sternapodeme 43 µm long. Virga apparently indicated by 2 very weak spines. Gonocoxite 98 µm long; inferior volsella very weak and low. Gonostylus 53 µm long, megaseta 11 µm long. HR 1.86, HV 2.84.

Etymology. – Named in honour of Godwin Amegabe, technician at Institute of Aquatic Biology, Achimota, Ghana, who participated in the collection of these new species.

Remarks. – *D. amegabei* sp. n. is very similar to *D. longipes* sp. n. described above. It has, however, a higher antennal ratio, stronger phallapodeme, and a more reduced inferior volsella. Since it also occurs together with *D. longipes* the two species are unlikely to be conspecific.

Distribution. – The species is known only from a rain forest in western Ghana close to the border with the Ivory Coast.

Georthocladius Strenzke

Georthocladius Strenzke, 1941: 185.
Orthocladius Goetghebuer *in* Strenzke, 1941: 177, nec v. d. Wulp.
Georthocladius subgen. *Atelopodella* Sæther, 1982: 488.
Toyamayusurika Sasa et Kawai, 1987: 62, **syn. n.**

Type species

Georthocladius luteicornis (Goetghebuer in Strenzke 1941: 177) by monotypy.

Diagnosis of male imago

As in Sæther & Sublette (1983: 23) and Cranston et al. (1989: 198) with the following emendations: Minute to moderately sized species; wing length 0.7-2.6 mm. Antennal ratio between 0.3 and 2.0. Antepronotum moderately to well developed. Anal lobe of wing reduced, nearly absent; squama fully fringed to bare; costa moderately to strongly extended. Gonostylus with bluntly pointed to rounded more or less pronounced outer corner; with sharply pointed, triangular outer heel; or with a very long pointed, slightly curved outer heel.

Included species. – In addition to the six species included in the key in Sæther & Sublette (1983) three species described from Japan in other genera clearly belong to *Georthocladius,* namely *Georthocladius asamasextus* (Sasa et Hirabayashi), **comb. n.** described as *Toyamayusurika asamasexta* by Sasa & Hirabayashi (1991: 125); *Georthocladius fujiquintus* (Sasa) **comb. n.** described as *Orthosmittia fujiquinta* by Sasa (1985: 125) and as *Toyamayusurika fujiquinta* by Sasa (1989: 133); and *Georthocladius shiotanii* (Sasa et Kawai), **comb. n.** described as *Toyamayusurika shiotanii* by Sasa & Kawai (1987: 62). *G. fujiquintus* is, in the original description, said to be lacking apical seta on the antenna as well as pulvilli. However, the similarities between *G. asamasextus* and *G. fujiquintus* are too

Figs 16-22. *Georthocladius longicalcaneum* sp. n., male imago. - 16, Cibarial pump, tentorium and stipes; 17, Third palpomere; 18, Thorax; 19, Wing; 20, Anal point and dorsal aspect of left gonocoxite and gonostylus; 21, Hypopygium with anal point and laterosternite IX removed, left dorsal aspect, right ventral aspect; 22, Gonostylus, ventral aspect.

great to be coincidental and the two species may be conspecific. *G. shiotanii* is very similar to *G. longicalcaneum* sp. n. described below, sharing for instance a unique synapomorphy in the triangular and curved outer heel of the gonostylus, and appear to form its sister species; while *G. fujiquintus (asamasextus)* is close to *G. amakyei* sp. n., the other *Georthocladius* described here. The two species described here as well as the Japanese species all differ from previously described species in the male hypopygium. They could represent the unknown males of the subgenus *Atelopodella*, but without knowledge of the immatures such a subgeneric placement is premature.

Georthocladius longicalcaneum sp. n.
(figs. 16-22)

Type material. – Holotype ♂, Ghana: Western region, Ankasa Game Production Reserve, 6-12.xii.1993, NUFU project (ZMBN No. 220).- Paratypes: 3 ♂, as holotype.

Diagnostic characters. – The small size (wing length 0.7-0.8 mm), absence of setae on squama, low antennal ratio (0.3-0.4), and the extremely long outer heel of the gonostylus will separate the species from all other *Doithrix*.

Male imago (n = 4 except when otherwise stated). – Total length 1.54-1.64, 1.61 mm. Wing length 0.71-0.76, 0.73 mm. Total length / wing length 2.15-2.25, 2.19. Wing length / length of profemur 2.34-2.43, 2.37. Coloration pale brown with vittae, median anepisternum II, ventral part of preepisternum and postnotum dark brown.

Head (figs. 16, 17). AR 0.36-0.44, 0.40. Ultimate flagellomere 105-150, 126 µm long; apical seta 26-34, 29 µm long. Temporal setae 7-12, 10; including 3-6, 5 inner verticals; 2-4, 3 outer verticals; and 2 postorbitals. Clypeus with 4-5, 5 setae. Tentorium 75-94, 85 µm long; 15-17, 16 µm wide. Stipes 64-75, 71 µm long; 15-19, 17 µm wide. Palp with 5 palpomeres, lengths (in µm): 15-21, 19; 21-30, 25; 53-58, 54; 68-83, 73; 64-83, 72. Third palpomere apically swollen, with about 6-7 sensilla clavata in 2-3 groups; fourth palpomere without apical sensillum clavatum.

Thorax (fig. 18). Antepronotum with 2-4, 3 setae. Dorsocentrals 11-13, 12; acrostichals about 6-8; prealars 5-6, 6, including 2-3, 3 posterior and 2-4, 3 anterior prealars. Scutellum with 4 setae.

Wing (fig. 19). VR 1.33-1.46 (3). Anal lobe reduced, not projecting. C extension 79-90, 86 µm long. Brachiolum with 1 seta; R with 2-4, 3 setae; other veins bare. Squama bare.

Legs. Spur of front tibia 26-30, 29 µm long; spurs of middle tibia 19-26, 21 µm and 17-19, 18 µm long; of hind tibia 34-41, 38 µm and 17-19, 19 µm long. Width at apex of front tibia 21-23, 23 µm; of middle tibia 21-23, 23 µm; of hind tibia 26-28, 27 µm. Hind tibial comb of 10-11, 11 setae; shortest setae 19-23, 22 µm long; longest setae 30-34, 32 µm long. Lengths and proportions of legs as in Table 3.

Hypopygium (figs. 20-22). Anal point 15-21, 19 µm long; with 9-12, 10 strong setae; laterosternite IX with 2-3, 3 setae. Phallapodeme 45-51, 49 µm long; transverse sternapodeme 26-34, 29 µm long. Gonocoxite 109-120, 116 µm long; inferior volsella triangular, with strong anteriomedially directed microtrichiae along median margin. Gonostylus 54-75, 66 µm long; with long, slightly curved outer heel; distance from base to apex of heel 56-75, 68 µm; to outer furcation between gonostylus and heel 36-41, 40 µm from base; gonostylus beyond heel tapering to apex; megaseta 8-11, 9 µm long. HR 1.60-2.00, 1.76; HV 2.19-2.98, 2.46.

Etymology. – From Latin, *longus*, long, and *calcaneum*, the heel, as a noun in apposition, referring to the long outer heel of the male gonostylus.

Remarks. – *G. longicalcaneum* sp. n. is very similar to *G. shiotanii* from Japan in the male hypopygium and appear to form its sister species. It is, however, only about half the size, have much lower chaetotaxy, lower antennal ratio, higher LR, and VR etc., all possible adaptations to a tropical climate.

Distribution. – The species is known only from a rain forest in western Ghana close to the border with the Ivory Coast.

Georthocladius amakyei sp. n.
(figs. 23-29)

Type material. – Holotype ♂, Ghana: Western region, Ankasa Game Production Reserve, 6-12. xii. 1993, NUFU project (ZMBN No. 219).

Diagnostic characters. – The species is similar to the preceding species in the small size, lack of setae on squama, and the low antennal ratio, but differ in having a shorter, triangular outer heel of the gonostylus.

Male imago (n = 1). – Total length 1.67 mm. Wing length 0.79 mm. Total length / wing length 2.11. Wing length / length of profemur 2.23. Coloration pale brown with vittae, median anepisternum II, ventral part of preepisternum and postnotum blackish brown.

Head (figs. 23, 24). AR 0.46. Ultimate flagellomere 154 µm long, apical seta 26 µm long. Temporal setae 7, including 4 inner verticals, 2 outer verticals, and 2 postorbitals. Clypeus with 7 setae. Tentorium 79 µm long, 17 µm wide. Stipes 77 µm long, 26 µm wide. Palp with 5 palpomeres, lengths (in µm): 19, 26, 54, 81, 86. Third palpomere apically swollen,

Table 3. Lengths (in µm) and proportions of legs of male imago of *Georthocladius longicalcaneum* sp. n.

	fe	ti	ta_1	ta_2
p_1	293-323, 310	315-338, 332	221-236, 230	139-158, 146
p_2	278-300, 289	285-308, 300	113-120, 116	60-71, 63
p_3	278-293, 286	304-347, 328	171-195, 184	79-98, 88

	ta_3	ta_4	ta_5	LR
p_1	105-120, 111	64-71, 67	41-45, 42	0.69-0.70, 0.69
p_2	47-56, 51	30-34, 33	26-30, 29	0.39
p_3	64-105, 87	34-43, 38	32-38, 35	0.55-0.56, 0.56

	BV	SV	BR
p_1	2.29-2.57, 2.44	2.73-2.82, 2.79	2.0-3.0, 2.4
p_2	3.80-4.28, 4.03	5.00-5.25, 5.09	2.0-2.7, 2.3
p_3	2.95-3.55, 3.35	3.28-3.41, 3.35	2.7-3.7, 3.2

with about 8 sensilla clavata in 2-3 groups; fourth palpomere without apical sensillum clavatum.

Thorax (fig. 25). Antepronotum with 3 setae. Dorsocentrals 11, acrostichals about 4, prealars 5, including 3 posterior and 2 anterior prealars. Scutellum with 4 setae.

Wing (fig. 26). VR 1.40. Anal lobe reduced, not projecting. C extension 83 µm long. Brachiolum with 1 seta, R with 2 setae, other veins bare. Squama bare.

Legs. Spur of front tibia 38 µm long, spurs of middle tibia 19 µm and 23 µm long, of hind tibia 41 µm and 19 µm long. Width at apex of front tibia 21 µm, of middle tibia 23 µm, of hind tibia 30 µm. Comb with 9 setae, 23-34 µm long. Lengths and proportions of legs as in Table 4.

Hypopygium (figs. 27-29). Anal point 19 µm long, with 14 strong setae, laterosternite IX with 3 setae. Phallapodeme 41 µm long, transverse sternapodeme 68 µm long. Gonocoxite 113 µm long; inferior volsella weak and low, rounded. Gonostylus 60 µm long; with short, sharply triangular outer heel; distance from base to apex of heel 38 µm; to outer furcation between gonostylus and heel 36 µm from base; gonostylus beyond heel tapering to apex; megaseta 8 µm long. HR 1.91; HV 2.79.

Etymology. – Named in honour of Joseph Somua Amakye, Senior research officer, Institute of Aquatic Biology, Achiomota, Ghana, who participated in the collection of these new species and is the liaison between the NUFU project and the Institute of Aquatic Biology.

Remarks. – *G. amakyei* sp. n. is similar to *G. fujiquintus* and *G. asamasextus* from Japan in the male hypopygium and may form their sister species. It is, however, only about half the size, have much lower chaetotaxy, lower antennal ratio, higher LR_1 and VR etc., all possible adaptations to a tropical climate.

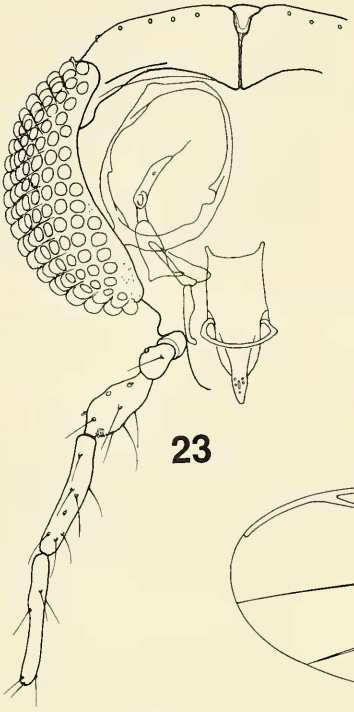
Distribution. – The species is known only from a rain forest in western Ghana close to the border with the Ivory Coast.

Notes on *Pseudorthocladius* Goetghebuer

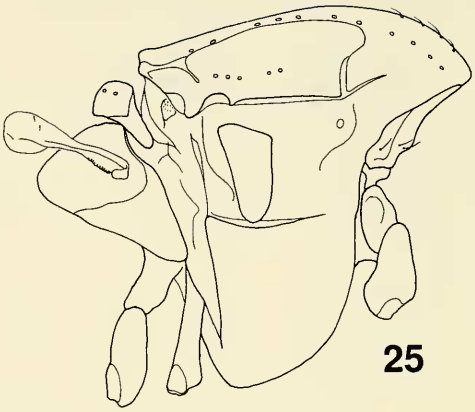
In addition to the 22 species mentioned in Sæther & Sublette (1983); including the Afrotropical *P. nigerrimus* Kieffer (Kieffer 1918), *P. similis* Freeman (Freeman 1953), and *P. bernadetti* Lehmann (Lehmann 1979), the following species have been described since the revision: *P. akanseptimus* Sasa et Kamimura, 1987, Japan; *P. amamikonaseus* (Sasa et Suzuki, 1993 as *Psectrocladius*) **comb. n.**, Japan; *P.*

Table 4. Lengths (in µm) and proportions of legs of male imago of *Georthocladius amakyei* sp. n.

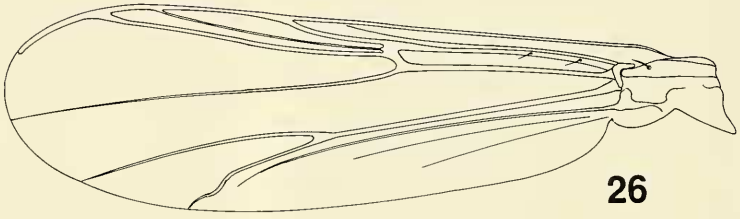
	fe	ti	ta_1	ta_2	ta_3	ta_4	ta_5	LR	BV	SV	BR
p_1	356	341	268	173	122	79	53	0.79	2.27	2.60	2.7
p_2	285	304	113	64	53	30	32	0.37	3.93	5.23	2.3
p_3	315	368	214	105	109	45	41	0.58	2.99	3.19	1.8



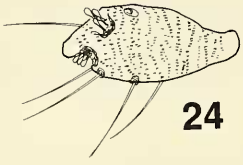
23



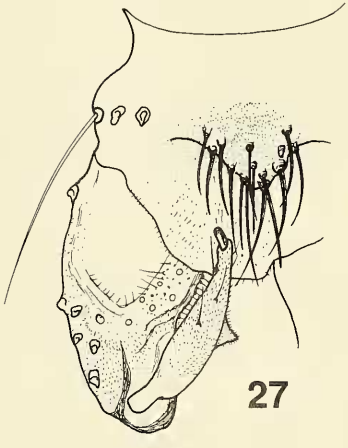
25



26

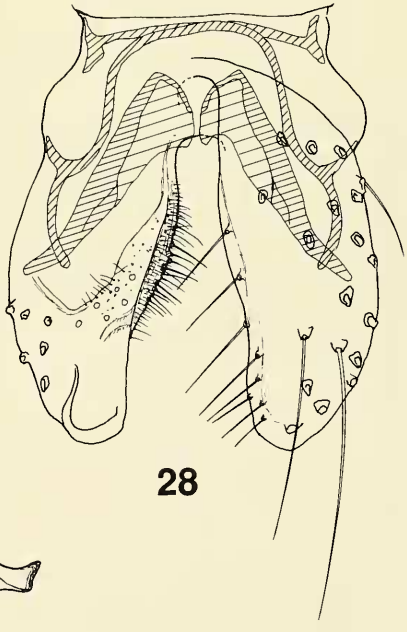


24



27

29



28

barthelemyi Mobayed, 1989, Bulgaria, France, Spain, Turkey, Morocco; *P. fujioctavus* Sasa, 1985, Japan; *P. kurobesugoidus* (Sasa et Okazawa, 1992 as *Psectrocladius*) **comb. n.**, Japan; *P. matusecundus* Sasa et Kawai, 1987, Japan; *P. rectangilobus* Caspers & Siebert, 1980, Germany, Norway; and *P. togakuroidus* (Sasa, Watanabe et Arakawa, 1992 as *Trissocladius*) **comb. n.**, Japan.

As mentioned by Sæther & Sublette (1983) the Afrotropical species are in need of revision and may not belong in the genus. *P. bernadetti* is stated to lack acrostichals and to have tiny pulvilli. If this is correct the species does not even belong in the *Pseudorthocladius* group. Sæther (1996) transferred *nigerrimus* to the genus *Mesosmittia* Brundin. *Pseudorthocladius similis* Freeman undoubtedly belongs in *Pseudorthocladius*. However, the redescription by Freeman (1956) may contain more than one species.

Adaptations of chironomids to tropical areas

Chironomid wing length was used by McLachlan (1985) to describe habitat characteristics. He suggested a negative relationship between wing length of most abundant species and duration or predictability of its habitat. This hypothesis was criticized by Vepsäläinen (1986) who argued that extrapolation of concepts on wing length and dispersal ability from intraspecific to the interspecific level was not valid. When studying terrestrial orthoclads inhabiting heathlands in Brittany in France Delettre (1988) found that two species which populations are strengthened or re-established by immigrants each year, did not have longer wings than two species with permanent larval populations. However, of the two former species migrant specimens had longer wings than resident specimens.

Sæther (1981) noted the small size, including the wing length, and the reduction of the anal lobe of the wing of the orthoclads from the West Indies compared with their closest relatives. Other apparent adaptations of tropical chironomids are loss of setae on squama, elongation of the costal extension, reduction of dorsomedian eye extension, narrowing of the tentorium, generally lower chaetotaxy, increased length of the front metatarsus resulting in a higher leg ratio, and often a reduction of the volsellae. However, not all these changes appear to take place in all species and certainly not always concurrently. Several of the characters in which changes take place are important in keys and phylogenies, and it is necessary to take the climatic conditions of where the species were collected into consideration when judging whether a character shows homoplasy or not. In order to judge whether a character is caused by such adaptation to a tropical climate or a tropical rain forest it is necessary to compare a species with its closest relative or relatives from more temperate areas. This is possible for the species described here and for a few other chironomids. Some comparisons are given in Table 5, where the bold characters indicate apparent adaptations to tropical areas, while those in italics show the inverse. Only comparison between species where the phylogenetic relationships has been elucidated, or clearly monophyletic genera where one species is from a tropical region, all the rest from the temperate region, are included.

As it will appear from table 5 tropical chironomids are smaller or of the same size as their closest relatives in temperate areas. Likewise the anal lobe is more reduced or of the same size, there are fewer or the same number of setae on the squama, the VR is higher or the same, the costal extension is longer or of the same length, the antennal ratio is lower or the same, the front leg ratio is higher or the same, and the inferior volsella is more reduced or equally developed. There are just two minor exceptions to this. In *Tokyobrillia anderseni* Sæther et Wang the antennal ratio is slightly higher than in *T. tamamegaseta* Kobayashi et Sasa, and in *Antillocladius zhengi* Wang et Sæther the antennal ratio is higher and the leg ratio lower than in *A. scalpellatus* Wang et Sæther. However, both these genera probably are of Gondwanian origin and primarily subtropical to tropical.

Coloration, size, and sometimes setal counts varies with temperature. When there are several generations a year the summer generations nearly always are smaller. As recently shown by Matena (1995) at increased development temperature an emerged adult is brighter and paler, and with variation in setal count and other morphometric features. But that is within the same species. The morphological features that go together with variation in development temperature (and therefore larval development temperature) coupled with isolation of populations through different phenology of cohorts could be (and probably is) the mechanism with which the tropical chironomids differentiated from their closest related more temperate species in the first place. On Madeira, for instance, the variation of nearly all the species also present on

Figs 23-29. *Georthocladius amakyei* sp. n., male imago. – 23, Head; 24, Third palpomere; 25, Thorax; 26, Wing; 27, Anal point and dorsal aspect of left gonocoxite and gonostylus; 28, Hypopygium with anal point and laterosternite IX removed, left dorsal aspect, right ventral aspect; 29, Gonostylus, ventral aspect.

Table 5. Comparison between some tropical orthoclads (Trop.) and their closest related temperate or subtropical (Temp.) species or species groups. (Data from Hirvenoja 1973; Kobayashi & Sasa 1991; Oliver 1977; Sæther 1981, 1982, 1985a, 1985b,1988; Sæther & Wang 1992, 1995; Wang & Sæther 1993) (abs= absent, flag.= flagellomeres, mod= moderately developed, red= reduced, str= strong, w= weak).

Name	Area	Wing length (mm)	Anal lobe	Squamal setae	VR	C extension, µm	AR	LR_1	Inferior volsellae
Doithrix longipes sp.n.	Trop.	1.3-2.0	red	0	1.4-1.5	83-110	0.2-0.3	1.01-1.04	low
D. amegabei sp.n.	Trop.	0.8	red	0	1.5	83	0.5	1.03	red
Doithrix spp.	Temp.	1.3-2.0	w-str	0-14	1.1-1.2	32-78	0.6-1.8	0.53-0.67	str
Georthocladius longicalcanus sp.n.	Trop.	0.7-0.8	red	0	1.3-1.5	79-90	0.4	0.69-0.70	mod
G. amakyei sp.n.	Trop.	0.8	red	0	1.4	83	0.5	0.79	red
Georthocladius spp.	Temp.	1.5-2.6	str	1-37	1.1-1.2	33-75	1.5-2.3	0.50-0.71	mod-str
Cricotopus nudisquamus Sæther	Trop.	0.9	red	0	1.1	43	-	0.50	str
C. mackenziensis Oliver	Temp.	1.1-1.6	str	4-9	1.1-1.2	-	1.1-1.4	0.53-0.62	str
C. canditibia Sæther	Trop.	1.4	-	1	1.1	59	-	0.64	str
C. festivellus gr.	Temp.	1.2-2.5	mod	5-10	1.0-1.4	shorter	1.0-1.6	0.52-0.66	str
Tokyobrillia anderseni Sæther et Wang	Trop.	*1.4-1.9*	w	3-6	1.5-1.8	71-113	*1.4-1.8*	0.85-0.86	str
T. tamamegaseta Kobayashi et Sasa	Temp.	1.3-1.7	w	4-10	1.6-1.7	-	1.2-1.6	0.48-0.52	str
Lipurometriocnemus glabalus Sæther	Trop.	0.9-1.3	mod	8-15	1.3-1.5	31-55	-	0.59-0.62	abs
L. vixlobatus Sæther	Temp.	1.2-1.6	mod	12-15	1.3-1.4	41-53	1.6-1.8	0.62	low
Mesosmittia truncata Sæther	Trop.	0.9	w	4	1.4	116	0.8	-	w
Mesosmittia spp.	Temp.	0.9-1.8	w	1-10	1.2-1.4	0-50	1.2-1.8	0.43-0.51	w-str
Diplosmittia harrisoni Sæther	Trop.	0.8-1.1	mod	0	1.3-1.4	0	0.6	0.31-0.34	red
D. recisus Sæther	Trop.	0.79	red	0	1.4	68	9 flag.	0.36	red
D. carinata Sæther	Temp.	1.1-1.3	mod	0	1.3-1.4	0	0.8	0.35-0.37	red
Antillocladius zhengi Wang et Sæther	Trop.	1.3	str	9	1.3	51	*1.7*	*0.68*	str
A. scalpellatus Wang et Sæther	Temp.	1.3-1.6	str	8-13	1.2-1.3	23-44	1.2-1.6	0.75-0.85	str
A. antecalvus Sæther	Trop.	0.9-1.1	w	1-3	1.4-1.5	47-61	-	0.74-0.77	str
A. arcuatus Sæther	Temp.	1.1-1.3	str	2-3	1.4	38-45	1.0-1.2	0.65-0.71	str
Paraphaenocladius impensus albusalatus Sæther et Wang	Trop.	1.2-1.6	w	4-6	1.1-1.2	34-68	0.4-0.5	0.78-0.81	str
P. impensus (Walker) *s.str.*	Temp.	1.3-1.9	w	7-10	1.1-1.2	38-81	0.8-1.0	0.68-0.72	str
P. exagitans longipes Sæther et Wang	Trop.	1.1-1.2	abs	3-7	1.2	45-60	0.4-0.6	0.90-0.98	str
P. exagitans (Johannsen) *s.str.*	Temp.	1.0-1.8	w	2-7	1.1-1.2	30-70	0.4-0.9	0.76-0.86	str
P. cuneipennis (Freeman)	Trop.	0.8-0.9	abs	2	1.1	44-56	0.5	0.72-0.73	str
P. dewulfi (Goetghebuer)	Trop.	0.9-1.2	red	1-3	1.1-1.2	56-81	0.5-0.6	0.74	str
P. crassicaudatus Sæther et Wang	Trop.	1.1-1.2	w	3-4	1.2	81-88	0.7	-	str
P. irritus group	Temp.	1.1-2.0	w- str	2-15	1.1-1.3	41-96	0.7-1.2	0.52-0.72	str

the European continent are within the total variation, but within a narrow range at the lower end of variation. They appear to be incipient species.

However, temperature alone cannot explain the difference between tropical species and their closest related temperate species. Rain forest populations of cosmopolitan or nearly cosmopolitan species such as *Limnophyes natalensis* (Kieffer) and *Harnischia curtilamellata* (Malloch), both present in the Ghanaian rain forest, although at the lower end of the range of morphological variation do not fall outside the total range of variation in temperate populations. In *L. natalensis* two populations differ in being smaller in nearly all measurements from other populations, one is from the rain forest of Zaïre, the other from Central Norway! Also in the comparisons made by us the temperate species often are from an equally hot climate as that found at least in the Ghanaian rain forest.

Certainly the habitat predictability of semiaquatic chironomids is high in a tropical rain forest with available habitats permanently present. This habitat

predictability appears to be reflected in the smaller range of variation in morphological features in tropical species when compared to the very variable populations of the same species or to the sister species in temperate areas. When comparing species within a monophyletic group MacLachlan's theory thus appear to hold.

The table above includes orthoclads only. However, the adaptations to tropical areas are the same for other subfamilies perhaps with the exception of the reduction of volsellae. Preliminary examinations of several new species from Ghana of the genus *Rheotanytarsus* Thienemann et Bause, each with close European sister species, show that the reduction in size and antennal ratio here may be at least as pronounced.

Acknowledgements

The project in Ghana is funded by The Norwegian Universities' Committee for Development, Research and Education (NUFU). Thanks are due to Joseph S. Amakye and the staff at the Institute of Aquatic Biology, C.S.I.R., Accra, Ghana for field assistance and to the Ghana Wildlife Department, Accra, Ghana for permission to collect in Ankasa Game Production Reserve. Gladys Raminez made the slide preparations.

References

Caspers, N. & M. Siebert, 1980. *Pseudorthocladius rectangilobus* sp. n. eine neue Chironomide aus dem Hunsrück (Deutschland) (Diptera: Chironomidae). – Mitteilungen der Schweizerische entomologischen Gesellschaft 53: 181-183.

Cranston, P. S. & D. R. Oliver, 1988. Additions and corrections to the Nearctic Orthocladiinae (Diptera: Chironomidae). – Canadian Entomologist 120: 425-462.

Cranston, P. S., D. R. Oliver & O. A. Sæther, 1989. The adult males of Orthocladiinae (Diptera: Chironomidae) of the Holarctic region – Keys and diagnoses. Pp. 165-352 *In:* Wiederholm, T. (ed.): Chironomidae of the Holarctic region. Keys and diagnoses. Part 3. Adult males. – Entomologica scandinavica, Supplement 34, 532 pp.

Delettre, Y. R., 1988. Chironomid wing length, dispersal ability and habitat predictability. – Holarctic Ecology 11: 166-170.

Freeman, P., 1953. Chironomidae (Diptera) from Western Cape Province I. – Proceedings of the Royal entomological Society of London 22: 127-135.

Freeman, P., 1956. A study of the Chironomidae (Diptera) of Africa south of the Sahara. Part II. – Bulletin of the British Museum (Natural History), Entomology 4: 287-368.

Hirvenoja, M., 1973. Revision der Gattung *Cricotopus* van der Wulp und ihrer Verwandten (Diptera, Chironomidae). – Annales zoologici fennici 10: 1-363.

Kieffer, J. J., 1918. Chironomides d'Afrique et d'Asie conservé au Muséum National Hongrois de Budapest. – Annales historico-naturales Musei nationalis Hungarici 16: 31-136.

Kobayashi, T. & M. Sasa, 1991. Description of two new species of the chironomid midges collected from the Tama River, Tokyo (Diptera, Chironomidae). – Japanese Journal of sanitary Zoology 42: 71-75.

Lehmann, J., 1979. Chironomidae (Diptera) aus Fliessgewässern Zentralafrikas (Systematik, Ökologie, Verbreitung und Produktionsbiologie). Teil I: Kivu-Gebiet, Ostzaire. – Spixiana, Supplement 3, 144 pp.

Matena, J. 1995. Polymorphism of *Chironomus plumosus* (L.) (Diptera: Chironomidae) males from a temperate fish-pond population. – European Journal of entomology 92: 699-703.

McLachlan, A., 1985. The relationship between habitat predictability and wing length in midges (Chironomidae). – Oikos 44: 391-397.

Mobayed, Z., 1989. Description de *Pseudorthocladius (Pseudorthocladius) berthelemyi* n. sp. (Dipt. Chironomidae, Orthocladiinae). – Bulletin de la Société d'Histoire naturelle de Toulouse 125: 27-29.

Oliver, D. R., 1977. *Bicinctus* - group of the genus *Cricotopus* van der Wulp (Diptera: Chironomidae) in the Nearctic with a description of a new species. – Journal of the Fisheries Research Board of Canada 34: 98-104.

Sæther, O. A., 1969. Some Nearctic Podonominae, Diamesinae and Orthocladiinae (Diptera: Chironomidae). – Bulletin of the Fisheries Research Board of Canada 170, 154 pp.

Sæther, O. A., 1980. Glossary of chironomid morphology terminology (Chironomidae: Diptera). – Entomologica scandinavica, Supplement 14, 51 pp.

Sæther, O. A., 1981. Orthocladiinae (Diptera: Chironomidae) from the British West Indies, with descriptions of *Antillocladius* n. gen., *Lipurometriocnemus* n. gen., *Compterosmittia* n. gen. and *Diplosmittia* n. gen. – Entomologica scandinavica, Supplement 16, 46 pp.

Sæther, O. A., 1982. Orthocladiinae (Diptera: Chironomidae) from S.E. USA, with descriptions of *Plhudsonia, Unniella, Platysmittia* n. genera and *Atelopodella* n. subgen. – Entomologica scandinavica 13: 465-510.

Sæther, O. A., 1985a. The imagines of *Mesosmittia* Brundin, 1956, with the description of seven new species (Diptera, Chironomidae). – Spixiana, Supplement 11: 37-54.

Sæther, O. A., 1985b. *Diplosmittia carinata* spec. nov. from Michigan (Diptera, Chironomidae). – Spixiana, Supplement 11: 55-57.

Sæther, O. A., 1988. *Diplosmittia recisus* spec. nov. from Peru (Diptera, Chironomidae). – Spixiana, Supplement 14: 45-47.

Sæther, O. A., 1996. Afrotropical records of the orthoclad genus *Mesosmittia* Brundin (Diptera: Chironomidae). – Spixiana (in press).

Sæther, O. A. & J. E. Sublette, 1983. A review of the genera *Doithrix* n. gen., *Georthocladius* Strenzke, *Parachaetocladius* Wülker and *Pseudorthocladius* Goetghebuer (Diptera: Chironomidae, Orthocladiinae). – Entomologica scandinavica, Supplement 20, 100 pp.

Sæther, O. A. & X. Wang, 1992. *Euryhapsis fusciprope*s sp. n. from China and *Tokyobrillia anderseni* sp. n. from Tanzania, with a review of genera near *Irisobrillia* Oliver (Diptera: Chironomidae). – Annales de Limnologie 28: 209-223.

Sæther, O. A. & X. Wang, 1995. Revision of the genus *Paraphaenocladius* Thienemann, 1924 (Diptera: Chiro-

nomidae). – Entomologica scandinavica, Supplement 48, 69 pp.
Sasa, M., 1985. Studies on the chironomids collected from lakes in the Mount Fuji area. – Research Report from the National Institute for environmental Studies 83: 101-160.
Sasa, M., 1989. Chironomidae of Japan: Checklist of species recorded, key to males and taxonomic notes. – Research Report from the National Institute for environmental Studies 125: 1-177.
Sasa, M. & K. Hirabayashi, 1991. Studies on the chironomid midges (Diptera, Chironomidae) collected at Kamikochi and Asama-Onsen, Nagano Prefecture. – Japanese Journal of sanitary Zoology 42: 109-128.
Sasa, M. & K. Kamimura, 1987. Chironomid midges collected on the shore of lakes in the Akan National Park, Hokkaido (Diptera, Chironomidae). – Research Report from the National Institute for environmental Studies 104: 9-61.
Sasa, M. & K. Kawai, 1987. Studies on the chironomid midges of the stream Itachigawa, Toyama. – Bulletin of Toyama Science Museum 10: 25-72.
Sasa, M. & T. Okazawa, 1992. Studies on the chironomid midges (yusurika) of Kurobe River. – Research Report from the Toyama Prefectural environmental Pollution Research Center 1992: 40-91.
Sasa, M. & H. Suzuki, 1993. Additional records of Chironomidae from Amami Island. – Research Report from the Toyama Prefectural environmental Pollution Research Center 1993: 110-124.
Sasa, M., M. Watanabe & R. Arakawa, 1992. Additional records of Chironomidae from Toga-Mura, 1992. – Research Report from the Toyama Prefectural environmental Pollution Research Center 1992: 231-246.
Strenzke, K. 1941. Terrestrische Chironomiden X: *Georthocladius luteicornis* Goetgh. – Zoologischer Anzeiger 135: 177-185.
Strenzke, K., 1950. Systematik, Morphologie und Ökologie der terrestrischen Chironomiden. – Archiv für Hydrobiologie, Supplement 18: 209-414.
Ueno, R. & T. Iwakuma, 1996. Chironomid fauna of the Miyatoko mire. – Pp. 59-62. In: T. Iwakuma (ed.), Mires of Japan. Ecosystems and monitoring of Miyatoko, Akaiyachi and Kushiro mires. – National Institute for Environmental Studies, Tsukuba, 127 pp.
Vepsäläinen, K., 1986. Chironomid wing length: a measure of habitat duration and predictability? - Oikos 46: 269-271.
Wang, X., 1994. *Doithrix emeiensis* sp. nov. from China (Diptera: Chironomidae). – Acta scientarum naturalium Universitatis Nankaiensis 1: 68-70.
Wang, X. & O. A. Sæther, 1993. First Palaearctic and Oriental records of the orthoclad genus *Antillocladius* Sæther (Diptera: Chironomidae). – Entomologica scandinavica. 24: 227-230.

Received: 25 October 1995
Accepted 21 May 1996